

# DEC SCR Converter<sup>TM</sup> system

## General system description

### Introduction

DEC SCR Converter system is a catalytic exhaust treatment system which reduces NO<sub>x</sub> to N<sub>2</sub> and water. It is exclusively developed for marine diesel engines, fully automatic and characterised by low complexity, high efficiency, long service life and a compact design.

As an option, the system includes an Oxidation catalyst, which further oxidises VOC and CO to CO<sub>2</sub> making the exhaust free of typical diesel odour and substantially reducing the human health risk.

The converter can be equipped with a silencer section for a total noise reduction of 25-35 dB or according to requirements.

The system is designed to meet the most stringent NO<sub>x</sub> regulations that have been enforced in Sweden in year 1998 and 2005. The design is based on the experience gained since the first delivery in 1991 and includes more than 200 marine SCR systems presently in operation or under construction.

### Exhaust emissions and performance

The SCR Converter system can be designed to meet emission performance within a wide range:

**NO<sub>x</sub>** (nitrogen oxides) are formed by N<sub>2</sub> (nitrogen) and O<sub>2</sub> (oxygen), mainly from the inlet air, during the high temperature combustion in the diesel engine.

**Typical design value: 20-99 % NO<sub>x</sub> reduction in the SCR**

**VOC** (volatile organic compounds) are formed by unburned fuel and lubrication oil and include various hydrocarbons and especially the carcinogenic PAH (poly-aromatic hydrocarbons).

**Typical design value: 70-90 % VOC reduction in the SCR**

**CO** (carbon monoxide) is formed by incompletely burned fuel and lubrication oil but it also comes from oxidised VOC and soot in the SCR. An oxidation catalyst can be added to the SCR in case there are restrictions on the CO emissions.

**Typical design value: 50 - 90 % CO reduction in the OXI**

**Noise.** The catalyst act as a 10-20 dB(A) silencer without any special considerations. By including an integrated or added silencer section the noise reduction can be designed according to specific requirements.

**Typical design value: 10 - 35 dB(A) noise reduction**

## DEC – Diesel Emission Control



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## Operating principle

NO<sub>x</sub> is reduced by SCR (Selective Catalytic Reduction). A small amount of urea / water solution is injected into the hot exhaust gas where it is vaporised and contacted with NO<sub>x</sub> in a heterogeneous catalysis over the SCR catalysts.

There are no waste products involved with the SCR process and the NO<sub>x</sub> reduction rate can easily be varied to meet different air pollution regulations by adjusting the urea injection rate between 0-100%.

The SCR Converters will be working with urea injection under the following temperature conditions:

Fuel type	DO	MDO	HFO	HFO
Sulphur content	< 0,1 %	< 0.25 %	< 1 %	< 5 %
Urea injection, min temp.	270°C	280°C	290°C	300°C

For continuous operation the exhaust gas temperature should be within 320 - 500 °C in order to avoid low temperature fouling or over heating.

The exhaust gas composition varies from time to time depending on the condition of the engine, ambient conditions, engine load and the amount of foreign substances that are introduced into the combustion chambers via impurities in the fuel and lubricating oil or the combustion air. Particularly the ash, CCR, Phosphorus and Arsenic content of the fuel influences the lifetime of the catalyst. Fuel oil blended with ULO (Used Lubricating Oil) should be avoided, due to high concentrations of additives.

Depending on the operating conditions and fuel oil quality, the performance of the catalysts is reduced over time. Normally the SCR converter system can be operated during 12,000-100,000 hours before used catalyst (SCR and OXI) is replaced or fresh catalyst is added.

## System function

Urea is supplied by the service pump system via a control valve to respective injector. The injector is fitted in the injection section located before the SCR Converter. The injection of urea into the exhaust duct is augmented by pressurised injection air in order to atomise the urea solution and to purge the injector from urea solution after injection shut off. Downstream the injection section, static mixers are fitted into the exhaust piping. The mixers make sure that the exhaust and the vaporised urea are mixed to a homogenous gas flow before entering the SCR Converter.

In the SCR Converter casing are different layers of catalyst material placed on elastically mounted shelves. The first layers are equipped with SCR catalysts followed by one layer with Oxidation catalysts when applicable. The silencer section is normally located within the same casing, when included.

The Control Metering Unit receives load and RPM signal from respective diesel engine. The signals are used for controlling the urea injection flow to suit the different engine load conditions according to the pre-set injection curve. Optionally is a signal from an NO analyser instrumentation used for automatic trend adjustments of the injection curve.

## **Converter, injection and mixing sections**

### **SCR Converter**

The SCR and Oxidation catalyst consists of ceramic monoliths/blocks packed side by side in multiple layers inside the converter casing. The catalyst blocks have narrow channels and are coated with catalytic active materials such as metals or their oxides. The open area is typically >65% thus providing an extremely large contact surface.

### **Injection and mixing sections**

The injection and mixing section is arranged before the SCR converter. The section includes flow dresser, fitting for the urea injector and static mixer elements.

For two stroke diesel applications a solution with pre-turbo located SCR converter is available.

### **Dust blowing system**

The Calcium content in the lubricating oil, as well as in the fuel oil, influences the formation of Calcium Sulphate after the combustion chamber. This happens irrespective of whether there is an SCR system installed or not. Calcium Sulphate (Gypsum powder) will deposit on the front of the catalysts, unless removed regularly with an effective dust blowing system.

The Munters SCR converters are equipped with a well-proven dust blowing system that is automatically operated on the ships starting or service air system. The system is designed for low air consumption and relies on air jets from a series of fixed lances inside the converters. Dust blowing duration and intervals are adjustable via the control panel.

The automatic dust blowing system also adds extra safety in situations like engine combustion malfunction or poor / uneven fuel oil quality.

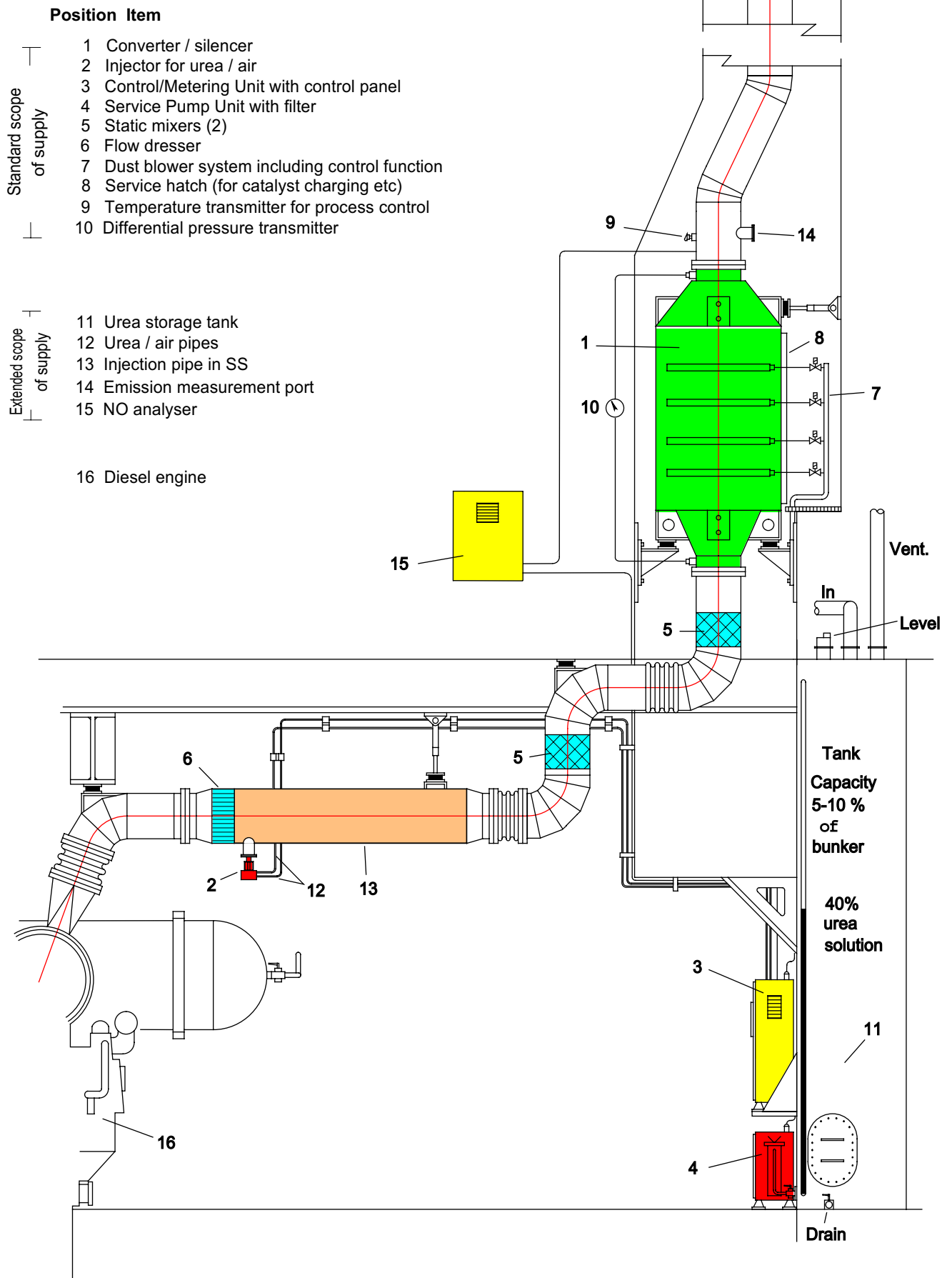
### **Urea tankage**

Urea,  $(\text{NH}_2)_2\text{CO}$ , is a common chemical commodity used in a wide range of products. For NO<sub>x</sub> reduction is urea normally delivered as a ready mixed solution with 40% urea and 60% de-ionised water, specific weight about 1112 kg / m<sup>3</sup> at 20°C. Steel tanks should be internally coated with epoxy or similar and pipes and fittings should be made of stainless steel or plastic material (Urea is corrosive on Copper and its alloys).

The consumption of urea solution is generally within 5-8% (wt) of the fuel consumption depending on the desired NO<sub>x</sub> reduction versus the base line emission. The consumption of urea is always proportional to the amount of NO<sub>x</sub> reduced.

# DEC SCR Converter™ system

## Typical arrangement



# DEC SCR Converter™ system - REFERENCE LIST MARINE INSTALLATIONS

	Ship				Engine				Delivery	
	Name	Owner	Yard	Type	Make	Type	Power	No	Equipment <sup>a)</sup>	Year
1	Aurora	Scandlines	Langsten 157	RoPax	Wärtsilä	6R32	2,46	1x	SCR / OXI	1991
2	Scandica	SNMA	Retrofit	Supply/ Ice breaker	Hedemora	VA16	1,30	2x	SCR / OXI	1994
3	RN 23	Royal Navy	Test bed	Frigate	Scania	DSI14	0,25	4x	SCR / OXI	
4	Atle	SNMA	Retrofit	Ice breaker	Paxman	12RPA2002	1,30	1x	SCR / OXI / IS	1995
5	Finnclipper	FG-shipping	AESA 78	RoPax	Pielstick	12PC2-2V	3,68	5x	SCR / OXI / IS	1996
6	Finneagle	FG-shipping	AESA 79	RoPax	Wärtsilä	624TS	0,66	4x	SCR / OXI / IS	
7	Constructor	Cofflex Inc	Containercat	Supply	Wärtsilä	424TS	0,35	1x	SCR / OXI / IS	
8	Spaaneborg	Wagenborg	Flender 676	RoRo	Sulzer	8ZAL40S	5,80	4x	SCR / OXI	1997
9	Schieborg	Wagenborg	Flender 677	RoRo	Sulzer	8S20U	1,16	3x	SCR / OXI	
10	Slingeborg	Wagenborg	Flender 678	RoRo	Sulzer	8ZAL40S	5,80	4x	SCR / OXI	1997
11	Stena Britannica	Stena RoRo	AESA 80	RoPax	Sulzer	8S20U	1,16	3x	SCR / OXI	
12	Stena Hollandica	Stena RoRo	AESA 81	RoPax	Sulzer	8ZAL40S	6,00	4x	SCR / OXI	1999
13	Tor Viking	B&N Viking	Leirvik 282	Supply/ Ice breaker	Sulzer	8S20U	1,16	3x	SCR / OXI	
14	Balder Viking	B&N Viking	Leirvik 283	Supply/ Ice breaker	Sulzer	8ZAL40S	6,00	4x	SCR / OXI	1999
15	Vidar Viking	B&N Viking	Leirvik 284	Supply/ Ice breaker	Sulzer	8S20U	1,16	3x	SCR / OXI	
16	Anke Ehler	Ehler	Sietas 1134	Container	Sulzer	8ZAL40S	6,00	4x	SCR / OXI	1999
17	Elisabeth	Holwerda	Sietas 1157	Container	Sulzer	8S20U	1,16	3x	SCR / OXI	
18	Dalsland	Holwerda	Sietas 1158	Container	Sulzer	8ZAL40S	6,00	4x	SCR / OXI	1999
19	Mikal With	Egil Ulvan	Vaagland 130	Cargo	Sulzer	8S20U	1,16	3x	SCR / OXI	
20	Stena Britannica	Stena RoRo	Hyundai 1392	RoPax	Sulzer	8ZAL40S	6,00	4x	SCR / OXI	2001
21	Stena Adventurer	Stena RoRo	Hyundai 1393	RoPax	Sulzer	8S20U	1,16	3x	SCR / OXI	
22	Nordford	FSF AS	Fiskerstrand 48	Ferry	Sulzer	8ZAL40S	6,00	4x	SCR / OXI	2001
23	Tor Magnolia	DFDS	Flensburg 721	RoRo	Sulzer	8S20U	1,16	3x	SCR / OXI	
24	Tor Petunia	DFDS	Flensburg 722	RoRo	Sulzer	8ZAL40S	6,00	4x	SCR / OXI	2003
25	Tor Primula	DFDS	Flensburg 723	RoRo	Sulzer	8S20U	1,16	3x	SCR / OXI	
26	Tor Begonia	DFDS	Flensburg 724	RoRo	Sulzer	8ZAL40S	6,00	4x	SCR / OXI	2003
27	Tor Freesia	DFDS	Flensburg 725	RoRo	Sulzer	8S20U	1,16	3x	SCR / OXI	
28	Balticborg	Wagenborg	Volharding 528	RoRo	Sulzer	8ZAL40S	6,00	4x	SCR / OXI	2004
29	Bothniaborg	Wagenborg	Volharding 529	RoRo	Sulzer	8S20U	1,16	3x	SCR / OXI	
30	Havila Troll	Havila Supply	Leirvik 077	Supply	Sulzer	8ZAL40S	6,00	4x	SCR / OXI	2003
31	Pearl of Scandinavia	DFDS	Retrofit	Cruise Ferry	Sulzer	8S20U	1,16	3x	SCR / OXI	
32	Crown of Scandinavia	DFDS	Retrofit	Cruise Ferry	Sulzer	8ZAL40S	6,00	4x	SCR / OXI	2004
33	Viking Cinderella	Viking Line	Retrofit Turku	Cruise Vessel	Sulzer	12ZAV40S	7,20	4x	SCR	2003
34	Princess of Scandinavia	DFDS	Retrofit	Cruise Ferry	Wärtsilä	6R32	2,46	4x	SCR / IS	
35	Bro Deliverer	Broström	Jinling 507	Tanker	MAN B&W	5L21/31	0,95	2x	SCR / OXI	2004
36	Bro Designer	Broström	Jinling 508	Tanker	MAN B&W	6L20	1,02	2x	SCR / OXI	2005
37		Broström	Jinling 509	Tanker	MAN B&W	7L27/38	2,38	2x	SCR / OXI / IS	2004
38		Broström	Jinling 510	Tanker	MAN B&W	6L16/24	0,60	4x	SCR / OXI / IS	
39	Obbola	Gorthon	Retrofit Öresundsvarvet	RoRo	MAN B&W	7L27/38	2,38	2x	SCR / OXI / IS	2005
40	Östrand	Gorthon	Retrofit Öresundsvarvet	RoRo	MAN B&W	6L16/24	0,60	4x	SCR / OXI / IS	
41	Tor Ficaria	DFDS	Flensburg 730	RoRo	MAN B&W	7L27/38	2,38	2x	SCR / OXI / IS	2005
42	Transpaper	Transatlantic	Aker Rauma 448	RoRo	MAN B&W	6L16/24	0,60	4x	SCR / OXI / IS	
43		Transatlantic	Aker Rauma 449	RoRo	MAN B&W	7L27/38	2,38	2x	SCR / OXI / IS	2005
44		Transatlantic	Aker Rauma 450	RoRo	MAN B&W	6L16/24	0,60	4x	SCR / OXI / IS	
45	Island Vanguard	Island Offshore	Aker Langsten 209	AHTS	MAN B&W	7L27/38	2,38	2x	SCR / OXI / IS	2005
46	Island Valiant	Island Offshore	Aker Langsten 210	AHTS	MAN B&W	6L16/24	0,60	4x	SCR / OXI / IS	
47	Hamlet	Scandlines	Retrofit Öresundsvarvet	RoPax	MAN B&W	7L27/38	2,38	2x	SCR / OXI / IS	2006
48	Tycho Brahe	Scandlines	Retrofit / ÖV	RoPax	MAN B&W	6L16/24	0,60	4x	SCR / OXI / IS	
49	Aurora af Helsingborg	Scandlines	Retrofit / ÖV	RoPax	MAN B&W	7L27/38	2,38	2x	SCR / OXI / IS	2006
50		Farstad	Aker Brevik 47	UT751	MAN B&W	6L16/24	0,60	4x	SCR	2006
51	Mokihana	Matson	Retrofit	Container	MAN B&W	8L27/38	2,64	1x	SCR / OXI / IS	2006
Total					221 engines		616 MW			

<sup>a)</sup> SCR = Selective Catalytic Reduction / OXI = Oxidation Catalyst / IS = Integrated Silencer

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